The Effect of Content Knowledge on Pedagogical Content Knowledge: The Case of Teaching Phases of Matters

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Abstract
The aim of the present research was to investigate the effect of the amount and quality of content knowledge on pedagogical content knowledge (PCK). The chemical content of phases of matters was used as an example. The research sample consisted of 28 science student teachers. The lesson preparation task, content knowledge test and semi-structured interview were used to collect data. This study shows that science student teachers have basic knowledge, few misconceptions and certain inadequacies at conceptual level. Science student teachers had understanding difficulties about relationship between concepts affected by their previous experiences. It has been seen that most student teachers had consistent content knowledge. The results of this study emphasize that content knowledge had positive influence on pedagogical content knowledge. Content knowledge also influenced effective teaching practice.

Key Words
Content Knowledge, Pedagogical Content Knowledge, Phases of

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Content knowledge is defined as “the concepts, principles, relationships, processes, and applications a student should know within a given academic subject, appropriate for his/her and organization of the knowledge.” Pedagogy is the science of teaching, instruction and training. Pedagogical content knowledge (PCK) was first introduced by Shulman (1986, 1987) and defined as teachers’ ways of representing and formulating the subject-matter knowledge in the context of facilitating student learning.

Some researchers have argued that there is not always a sharp distinction between PCK and subject matter knowledge because subject matter knowledge functions as a source to be transformed for teaching (Tobin, Tippins, & Gallard, 1994). On the other hand, student-teachers having inaccurate and inadequate knowledge might transfer their own misconceptions to their students (Hashweh, 1987) and in this way add to students’ conceptual difficulties (Even, 1993). Kaya (2008) showed that there was a significant interrelationship between the subject matter and pedagogical knowledge of the pre-service science teachers. Similarly, many researchers such as Halim and Meerah (2002), Van Driel, De Jong and Verloop (2002) concluded that content knowledge had influence on pedagogical content knowledge. However, content knowledge had no effect on pedagogical content knowledge according to Mapolelo (1999). The importance of content knowledge on pedagogical content knowledge is somewhat controversial and needs further study.

Teacher’s thinking as one of the components of effective teaching in recent years has been the focus of the research studies reported by Lederman and Niess, 2001; Ritchie, 1999; Connelly, Clandinin and He, 1997; Clark and Peterson, 1986; Uşak, 2005; Nakiboğlu et.al. 2005. Putnam (1987) and Borko, Livingstone and Shavelson (1990) stated that efficient teaching consists of packages of contents, goals and teaching methods.

Implemented teacher thinking in classroom interaction is the other type of teacher thinking. Marland & Osborne (1990) and Hogan, Rabinowitz & Craven (2003) concluded that this thinking during teaching concentrates more on students and ways to act rather than on the content. It has been seen that the teachers’ thinking was compared in the same category of experience related to researches about student teachers’ CK and PCK (Hogan et.al. 2003; Smith & Neale,
Besides this, Hashweh (1987) and Gess-Newsome (1999) argued that experienced teachers have applied their knowledge to teaching easily since they had more constructed knowledge.

Research into CK and PCK related to chemistry topics has been taken place in the literature in recent years. For example, De Jong et.al (2005) stated that most of the chemistry teaching master students had started to think deeper about students’ understanding difficulties for particulate nature of matter after applying a special education related to PCK. De Jong et.al (2004) concluded that macro, micro and symbolic meanings related to chemistry topics had developed 8 chemistry student teachers’ PCK. In a similar study, De Jong (2000) has found that a special program focused on transferring learning from teaching developed and increased the student teachers’ PCK in an experimental course. On the other hand, Mapolelo (1999) concluded that CK had no effect on PCK.

**Significance and Aims of the Study**

In this research, science student teachers’ understanding levels of concepts are examined as a relationship between content knowledge and pedagogical content knowledge. The topic of phases of matters was selected. The student teachers’ pedagogical content knowledge was compared by applying the lesson preparation method (Van der Valk, & Broekman, 1999). The study focused on finding out:

- What differences are found in science student teachers’ content knowledge?
- Does science student teachers’ content knowledge influence their pedagogical content knowledge (of conceptual difficulties of students, knowledge of curriculum, teaching methods and orientation in teaching)?
- What types of pedagogical problems do science student-teachers face when preparing their lesson plans?

**Method**

The method used for studying the influence of CK on PCK for science student-teachers was the lesson preparation method followed
by interviews (Van der Valk, & Broekman, 1999). The current study was conducted on the basis of three main components of PCK revised by Magnusson, Krajcik and Borko (1999), which was first proposed by Shulman (1986). These main components can be listed as conceptual difficulties of students, teaching goals (knowledge of curriculum) and orientation in teaching. De Jong, Ahtee, Goodwin, Hatzinikita, and Koulaidis (1999) used the same method for science student teachers’ PCK related to teaching the concept of burning. In addition, the same method was used by Frederik, Van der Valk, Leite, and Thorén (1999) in teaching the concepts of heat and temperature and also Oldham, Van der Valk, Broekman and Berenson (1999) related to teaching geometrical areas for mathematics student teachers.

**Participants**

This study was carried out with 28 science student teachers enrolled in the Department of Primary Science Education in Adıyaman University.

**Procedures and Instruments**

The lesson preparation task, content knowledge test, and semi-structured interviews were used to collect the data.

**Lesson Plans**

First, science student-teachers were invited to write individual lesson plans for a 2-hour teaching period on the topic of phases of matters for Grade 5 students (aged 11 years). They had 1 hour to write the lesson plans without any books or other material available. They were proctored by the researcher all the time. They were asked to work independently and not to discuss their plans with each other.

**The Content Knowledge Test (CKT)**

The lesson plan was followed immediately by the content knowledge test. This test was prepared after reviewing the relevant literature (Andersson, 1990; Nakhleh, Samarapungavan and Saglam, 2005; Stavy, 1990; Stavy and Stachel, 1985). It consists of the student-teachers’ own understanding of phases of matters and their ideas of students’ prior knowledge, alternative conceptions, and le-
arning difficulties within the topic. The test was placed after the lesson plan task so that it did not affect the lesson plan.

Semi-structured Interviews

The interviews took place within 3 weeks after the lesson plan. During the interviews, the student-teachers were encouraged to talk about their lesson plans and their difficulties in writing them. The purpose of the structured interviews (Appendix 1) was to study the student-teachers’ content knowledge, Pedagogical Content Knowledge and difficulties in lesson planning, and anticipated problems in teaching and perceived educational needs to perform successfully as a teacher. The duration of the interviews varied from 25 to 50 minutes depending on how much time student-teachers wanted to have.

Results

Science Student Teachers’ Content Knowledge

The understanding of phases of matters was analyzed by means of the lesson plans, the content knowledge test, and the semi-structured interviews. According to the available data, there is considerable variance in science student-teachers’ understanding of phases of matters in general. This study shows that science student teachers have basic knowledge with few misconceptions and inadequacies about phases of matters. Based on their understanding, three categories were formed (Käpylä et al., 2008):

Student-teachers’ Pedagogical Content Knowledge

Knowledge on Conceptual Difficulties of the Students

The student-teachers’ knowledge on the typical conceptual difficulties that students have concerning phases of matters was studied on the basis of their answers in the semi-structured interviews. Science student teachers had understanding difficulties about relationship between concepts affected by previous experiences. It has been seen that most student teachers had consistent content knowledge. The results of this study emphasized that content knowledge had positive influence on pedagogical content knowledge and effective teaching.
Main Teaching Goals (Knowledge on Curriculum)
The main teaching goals (knowledge on curriculum) were studied through student teachers’ interviews. Some student teachers emphasized the comparison of the phases of matter and more than half of the participants were focused comparison of phases supported by daily life examples.

Teaching Methods (Educational Activities)
The educational activities preferred by the student teachers were examined using both the lesson plans and the semi-structured interviews. First, the activities collected and then similarities were examined. Finally, educational activities were collected in five different categories. These categories were experimental work, making observation, drama, teaching by games and group working. Most student teachers preferred direct activities such as experimental work, making observation and group working.

Orientation to Teaching
The participants’ orientation to teaching was examined through the lesson plans and semi-structured interviews and the student teachers were classified by two categories as proposed by Adams and Krockover (1997). Furthermore, there are many categories in the literature classified by Magnusson and et.al., 1999; Anderson and Smith, 1987; Hashweh’s 1996; De Jong and et.al., 1999; Smith and Neale, 1989) but these categories were not used in this study because it was difficult to make an objective evaluation with these categories for this study. Student teachers had mostly preferred constructivist teaching approach (sixteen student teachers) in this study.

Problems in Lesson Planning
The problems in lesson planning and imaginary carrying-out of the lesson were studied using the interview. Four categories were formed: content knowledge; knowledge of the students’ understanding of natural science; motivation; and class control. The most common problem that science student-teachers mentioned was their insufficient knowledge of students’ scientific understanding. These problems appeared when they tried to figure out how students in the fifth grade think about this topic and what kind of prior knowledge they have. Sample lesson plans at different levels are shown in Appendix 2.
Perceived Educational Needs

The semi-structured interview was used to study the perceived educational needs of the science student teachers. The data were handled as described before and the final classifications were formed: CK; knowledge of teaching methods (activities) of science (PCK); knowledge of students understanding of science (PCK); knowledge of the curriculum of science (PCK) and experience or observation of teaching in the primary school. Majority of the science student-teachers mentioned the knowledge of teaching methods and knowledge about students’ understanding of science as the most important educational needs.

Discussion

Science student teachers had the basic knowledge on the topic named phases of matters. They had some misconceptions and inaccuracies on the phases of matters. The results of this study emphasized that content knowledge had positive influence on pedagogical content knowledge and effective teaching as reported by Gess-Newsome, J., & Lederman, N. G. (1995). The most important educational need stated by science student teachers was knowledge about students’ understanding of science. This result is consistent with the literature (Adams, & Krockover, 1997; Sanders, L., Borko, H., & Lockard, J. 1993; Schempp, P. G., Manross, D., Tan, S. K. S., & Fincher, M. D. 1998 and Stacey, K., Helme, S., Steinle, V., Baturo, A., Irwin, K., & Bana, J. 2001). This research suggests the view that Pedagogical Content Knowledge should be taught during teacher training supported by the study conducted by Clermont, Borko and Crajcik (1994). Teacher education program should consider the influence of content knowledge on pedagogical content knowledge as a central concept as stated by Jones, A., & Moreland, J. (2004); Zembal-Saul, Starr & Krajeik, 1999; Niess & Scholtz, 1999; Jones & Moreland, 2004; Mason, 1999). CK and PCK research should be simple and practical and help provide guide for conceptual tools for lesson planning. Content representation table combining professional and pedagogical experience proposed by Loughran, Mulhall & Berry (2004) and Loughran et.al. (2001) can be used in in-service training.
References/ Kaynakça


EK-1

MADDENİN FİZIKSEL HÂLLERİ PEDAGOJİK ALAN BİLGİSİ TESTİ

Adı ve Soyadı: 
Sinif ve Bölümü:

1) Biz öğretmen olarak maddenin hâllerini neden öğrenir ve neden öğrencilere öğretiriz?

2) Maddenin fiziksel hâlleriyyle ilgili olarak öğrencilere öğretmek istediğiniz en önemli konu nedir?
   a) Bu konunun neden çok önemli olduğunu düşünüyorsunuz?
   b) Dersinizde öğreteceğiniz başka önemli konular var mıdır? Varsa onların neden önemli olduğunu düşünüyorsunuz?

3) Maddenin hâlleri konusunu anlatırken ders esnasında ne tür sorunlarla karşılaşacağınızı düşünüyorsunuz? Neden?

4) Maddenin fiziksel hâlleriyile ilgili dersinizi anlattıktan sonra öğrencilere hangi yeni kavramları anlayacağıını düşünüyorsunuz?
   a) Öğrencilerinizin neden sadece o konuları öğreneceğini düşünüyorsunuz?
   b) Öğrencilerinizin öğreneceğini düşündüğünüz başka konular var mıdır? Neden öğrenciilerin sadece bu konuları öğreneceğini düşündüğünüz?

5) Genel olarak maddenin fiziksel hâllerı konusunu anlatmayı düşünüyüzde ne tür olumlu ve olumsuz düşunce ve duygular aкла gelmektedir? Neden?

6) Maddenin fiziksel hâllerı konusunu anlatırken en çok hangi bölümdede daha çok destek ve yardımcı ihtiyaç duyacağını düşünüyorsunuz? Neden?
Ek-2. Farklı düzeylerde hazırlanan ders planı örnekleri

Adı ve Soyadı: [Yazarın adı]
Sınıf ve Bölümü: [Sinif ve Bölüm]

Aşağıda verilen hedef ve sınav tasarımıınız davranışları kazandırmayı amaçlayan bir fen bilgisi öğretmeni oluşturunuz varsayarız. Maddenin fiziksel hallerini konusunu ilköğretim 5. sınıf düzeyindeki öğrencileri anlamlı için bir ders planı hazırlayınız.

Not: Ders planı hazırlanırken aşağıdaki öğrendikleri başlıklar kullanabilirsiniz.

1) Önerilen süre (ders saatli)
2) Konunun Amacı
3) Mühtemel konu başlıkları
4) Etkinlik Örneği
5) Değerlendirme Soruları

Hedef: Maddinin hallerini kavratabilme

Önerilen süre: [Süre belirtilmedi]
Konunun Amacı: [Amac belirtilmedi]
Maddenin hallerini kavratabilme, bunun nedeni konusuna,NotFound konunun oluşturulmasıyla ilgili olarak daha ileri düzeyde öğrenilecektir.

Konunun başında: [Konunun başlığı belirtilmedi]

Konunun başında: [Konunun başlığı belirtilmedi]

Konunun başında: [Konunun başlığı belirtilmedi]

Konunun başında: [Konunun başlığı belirtilmedi]

Etkinlik: Konunun altından, ders olarak alınan spesifik konunun sorunu çözme yeteneğini kazandırılmaktadır. Örneğin, maddenin hallerini kavratabilme, bunun nedeni konunun oluşturulmasıyla ilgili olarak daha ileri düzeyde öğrenilecektir.
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Adlı ve Soyadı: Oktayalp
Sınıf ve Bölümü: f. Fen Bilimleri
Apaçık durumda verilen hedef ve sorun tasarladığımız davranışları kazandırmayı amaçlayan bir fen bilgisi öğrenmeni ödeviğimiz varsayarız. Maddinin Fiziksel Halleri konusunu ilgilenen 5. sınıf dizeyindeki öğrencileri anlatmak için bir ders planı hazırlıyoruz.

Not: Ders planı hazırlarken apayrı olarak apayrı olarak kullanılabiliriz.

1) Önerilen süre (ders saatı)
2) Konunan Amacı
3) Mutlakel Konu başlıkları
4) Etkinlik Örnekleri
5) Değerlendirme Soruları

Ders saatı: 20 dakika
Konunan amacı: Maddinin fiziksel hallerini ögrenme ve işi biyomüze taşındırmak.

Maddinin Fiziksel Halleri: Örnekli modde nedir?

Maddi: Belirti bir hacim, vücut alan, besleme gel yapısı için, nesneler modde değil. Bu madde, su, hava, gazdır.

Sui, hava, gaz.

Suyun, gazın, hava, su.

Suyun, hava, gaz.

Hava, su.

Suyun besleme ve hava.

Gaz, su.

Suyun, su.

Hava, hava.

Gaz, su.

Suyun, besleme.

Gaz, besleme.

Suyun, besleme.

Hava, besleme.

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Suyun, besleme.

Gaz, besleme.